	Presenter:
	Organization/Date: Orbiter 01/09/03

BACKUP INFORMATION

	Presenter:
	Organization/Date: Orbiter 01/09/03

PREVIOUS FLIGHT ANOMALIES BACKUP

	Presenter:
	Organization/Date: Orbiter 01/09/03

STS-113 PREVIOUS FLIGHT ANOMALIES BACKUP

	Presenter:
	Organization/Date: Orbiter 01/09/03

STS-109 PREVIOUS FLIGHT ANOMALIES BACKUP

STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

Observation:

- Freon coolant loop (FCL) 1 aft cold plate (ACP) flow dropped from 305 to 225 lbs/hr after MECO

Concern:

- Flow rate reduction could result in loss of a FCL and early mission termination

Discussion:

- Approximately ten minutes after lift-off, the FCL 1 ACP flow rate dropped from 305 lbs/hr to 225 lbs/hr, then to 195 lbs/hr when the FCL was reconfigured to rad flow
  - Data review confirmed that the flow reduction was caused by a restriction in the ACP leg
- The flow rate stabilized, and analysis determined that adequate flow would still be available to provide sufficient cooling for the remainder of STS-109

STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

Actions Taken:

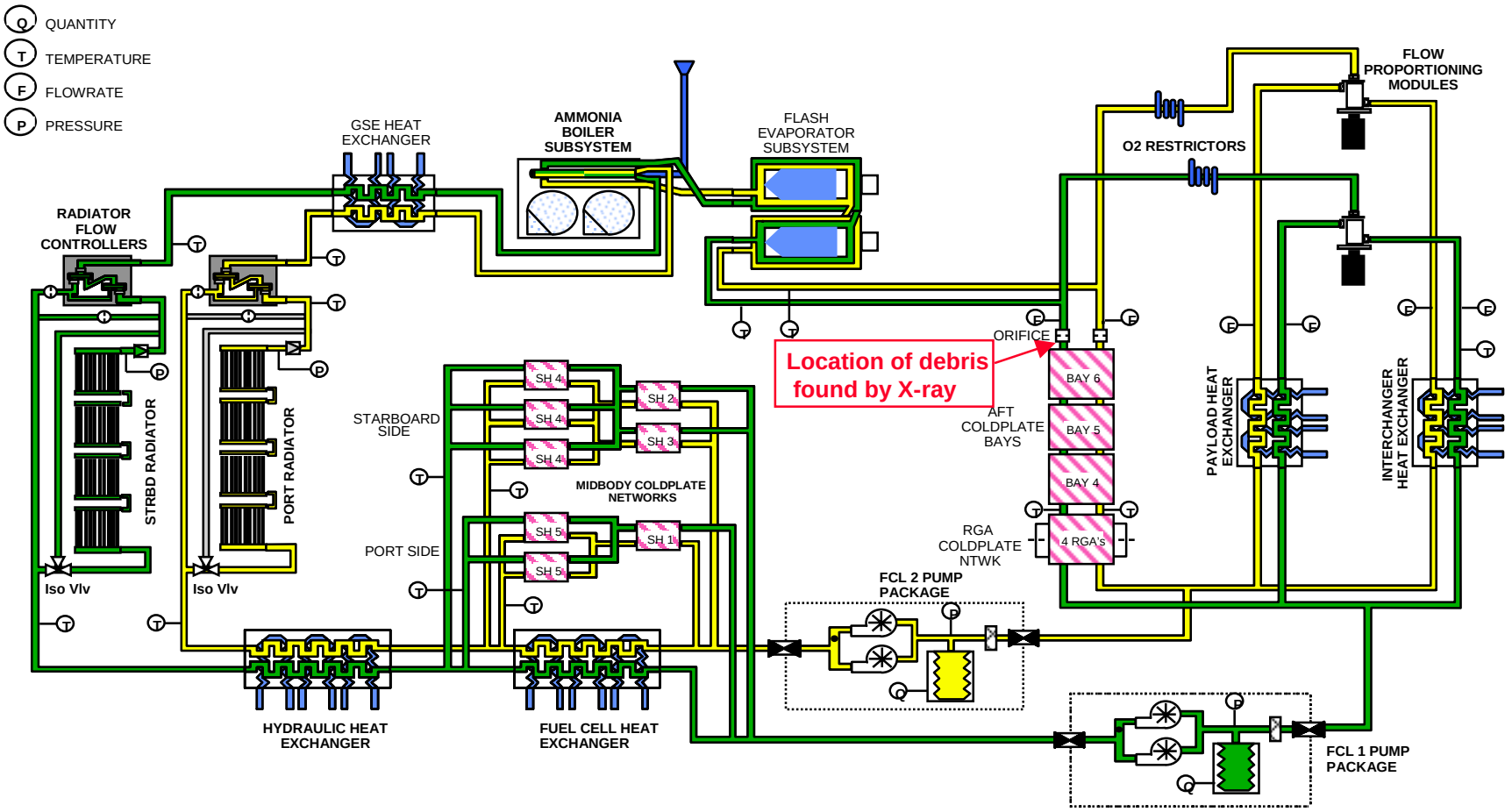
- During post-flight troubleshooting, a piece of debris was found stuck in the upstream side of the orifice between the FES and the aft coldplate network
- FCL 1 was de-serviced and de-brazed to allow extraction of the contaminant
  - Laboratory analysis confirmed that segment of braze preform became detached during brazing
- More x-rays were taken at other suspected locations after power-down to ensure no additional FOD is present in either loop 1 or 2 (see next slides)
  - Included x-rays of three potential traps in the RFCAs
- Visual inspections of FCL 1 FPM & pump inlet filters were also performed
  - FPM 1 and pump inlet filters replaced

STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW

Presenter:

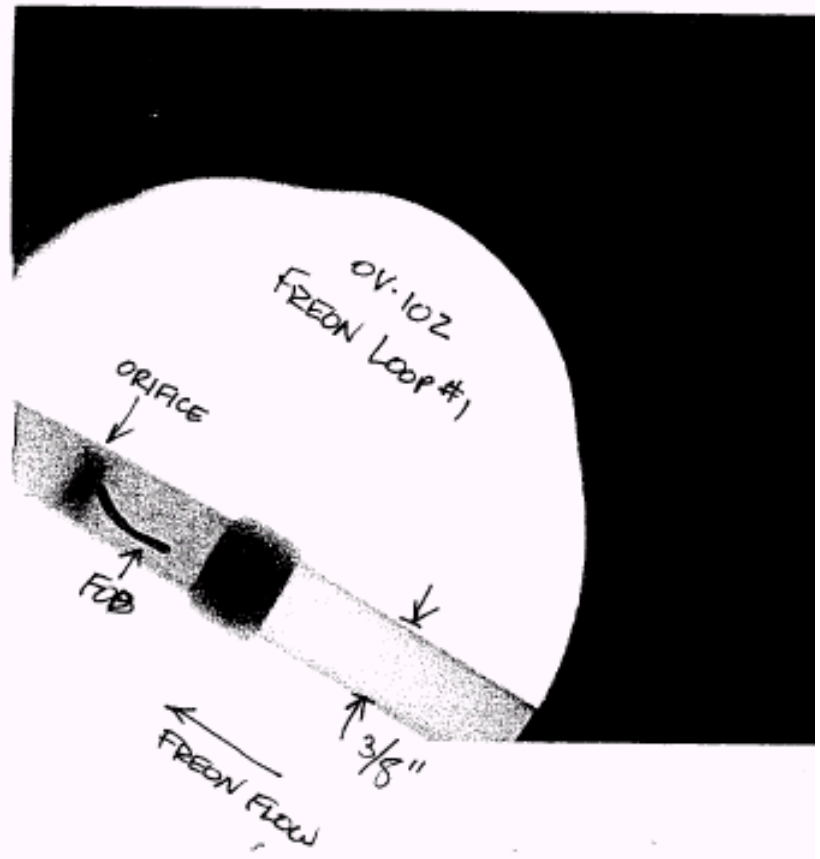
Organization/Date:
Orbiter 01/09/03

ORBITER ACTIVE THERMAL CONTROL SYSTEM (ATCS)



STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

Braze Preform Debris Found in the Upstream Side of the Orifice Between the FES and the Aft Coldplate Network

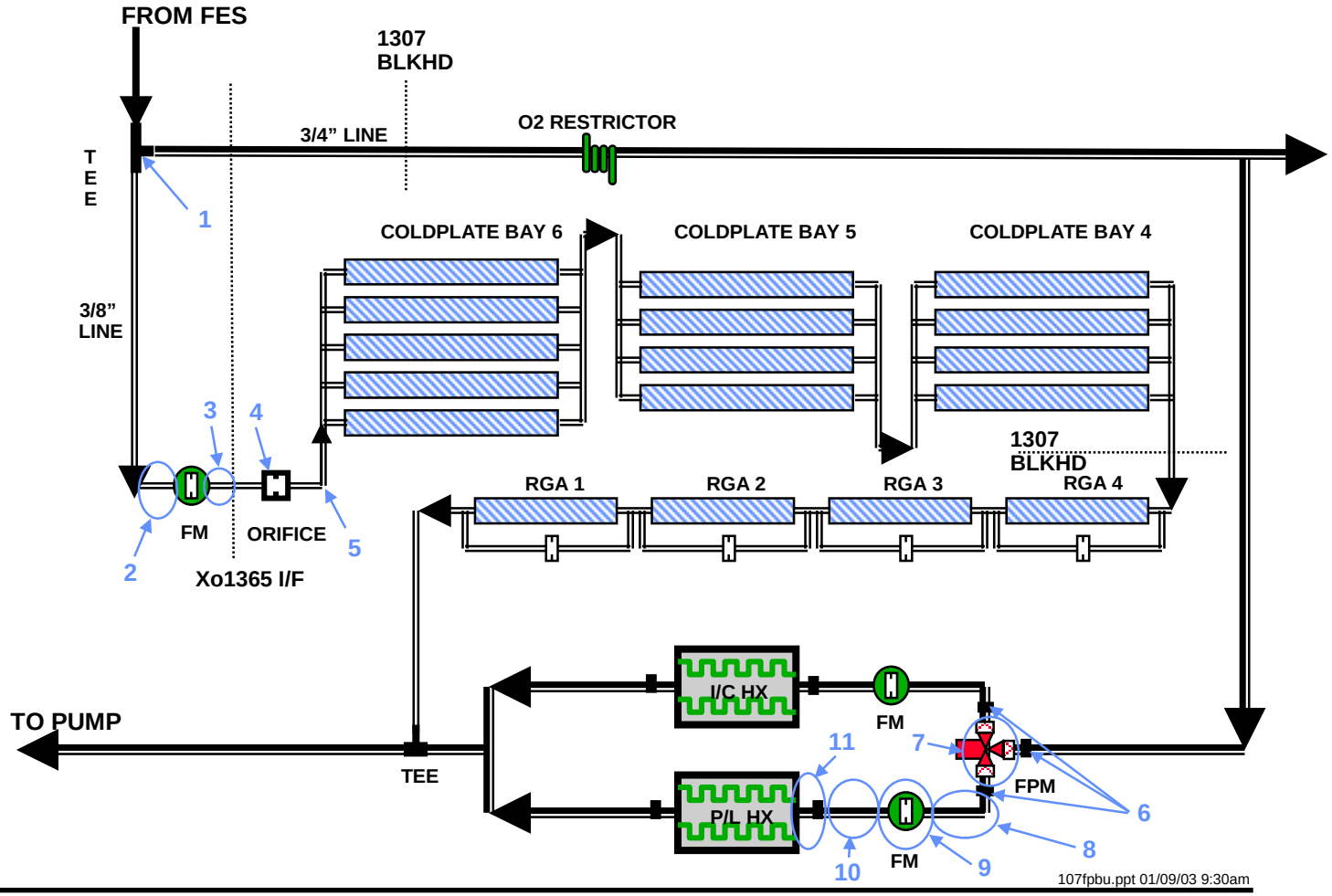


STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW

Presenter:

Organization/Date:
Orbiter 01/09/03

X-rayed Locations for Coldplate Network

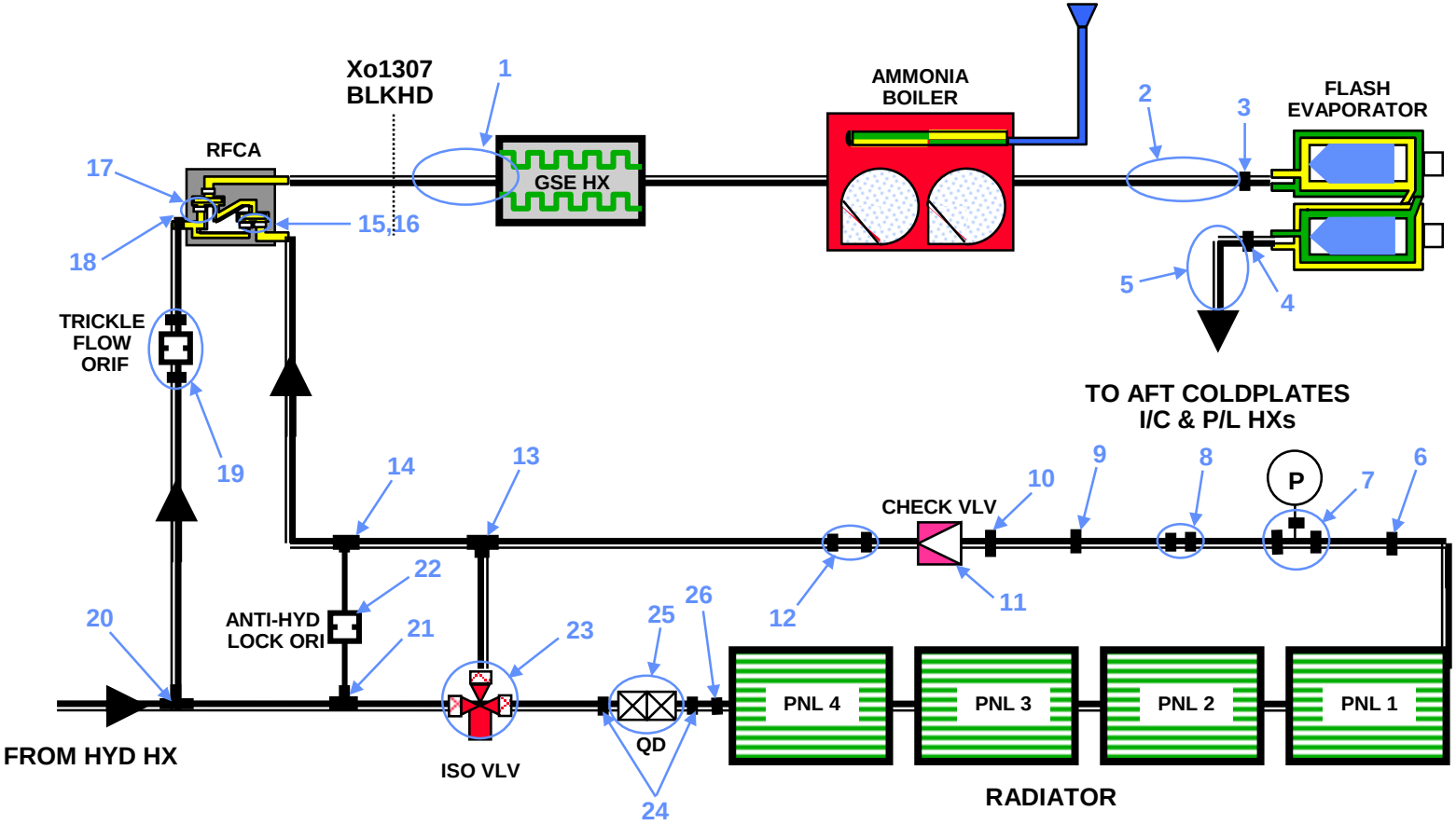


STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW

Presenter:

Organization/Date:
Orbiter 01/09/03

X-rayed Locations for FES, Radiator and RFCA



STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

Risk Assessment:

- Freon coolant system is criticality 1R2
- Two FCLs are required to support normal vehicle operations
- Loss of one loop results in next PLS
- Procedure for single FCL loop abort is documented

Flight Rationale:

- The debris that caused the flow restriction was removed
- Additional x-rays taken at potential debris traps in both loops and visual inspection of FCL 1 FPM & pump inlet filters verified acceptable system cleanliness
  - FPM 1 and pump inlet filters replaced
- Freon systems have been verified through OMRSD testing

STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

X-rayed Locations for Coldplate Network:

1 – ¾” – 3/8” reducer tee

2 – Coldplate flow sensor inlet braze/180 deg inlet tube bend

3 – Coldplate flow sensor outlet braze/90 deg outlet bend to X_O1365 bulkhead

4 – Coldplate flow orifice (debris lodged here)

5 – Avionics bay 6 inlet tube (90 deg bend) [FCL 1 only]

6 – FPM (Flow Proportioning Module) inlet/outlet brazes

7 – FPM inlet/outlet filters (3 each)

8 – FPM outlet tube bend including entire line to P/L flow sensor inlet

9 – Payload flow sensor including inlet/outlet brazes

10 – Entire line from payload flow sensor to inlet of P/L HX

11 – P/L HX inlet header and braze

STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

FCL 1 X-rayed Locations for FES, Radiator and RFCA:

1 – GSE HX inlet header/tube run upstream to 1st clamp

2 – FES inlet line from 1st line clamp upstream to inlet braze

3 – FES inlet braze

4 – FES outlet braze

5 – FES outlet line down to 1st clamp (including male/female mechanical fittings)

6 – Tube/tube braze

7 – Tee (3 brazes)

8 – Elbow to tube/flexline (2 brazes)

9 – Flexline braze to tube flange support

10 – Tube flange support outlet braze to dynatube braze TP231B

STS-109-V-01: FREON COOLANT LOOP 1 DEGRADED AFT COLD PLATE FLOW	Presenter:
	Organization/Date: Orbiter 01/09/03

X-rayed Locations for FES, Radiator and RFCA: (cont)

11 – Isolation check valve
12 – Elbow brazes to check valve/tube*
13 – Tee (3 brazes)*
14 – Tee (2 brazes), brazed to item 13 tee*
15 – RFCA flow control valve inlet filter (cold)
16 – RFCA flow control valve inlet filter (hot)
17 – RFCA bypass valve inlet filter
18 – RFCA bypass leg inlet braze*
19 – Bypass orifice including inlet/outlet brazes
20 – Tee (3 brazes)*
21 – Tee (2 brazes), brazed to item 20 tee
22 – Anti-hydraulic lock up orifice*
23 – Iso valve body and inlet/outlet brazes (3)
24 – QD inlet braze at flexline interface/QD outlet braze*
25 – QD interface male/female
26 – Tube to tube braze*

* Indicates FCL 1 only

STS-109-V-02: AIRLOCK A HATCH LOCKING DEVICE DIFFICULT TO ACTUATE	Presenter:
	Organization/Date: Orbiter 01/09/03

Observation:

- When the crew first attempted to open the internal airlock "A" hatch during STS-109, they reported that the actuator would not unlock when the lock tab was moved to the unlocked position
- The crew noticed that the removable handle was partially disengaged from the actuator, so they reseated it and were then able to unlock and unlatch the hatch successfully

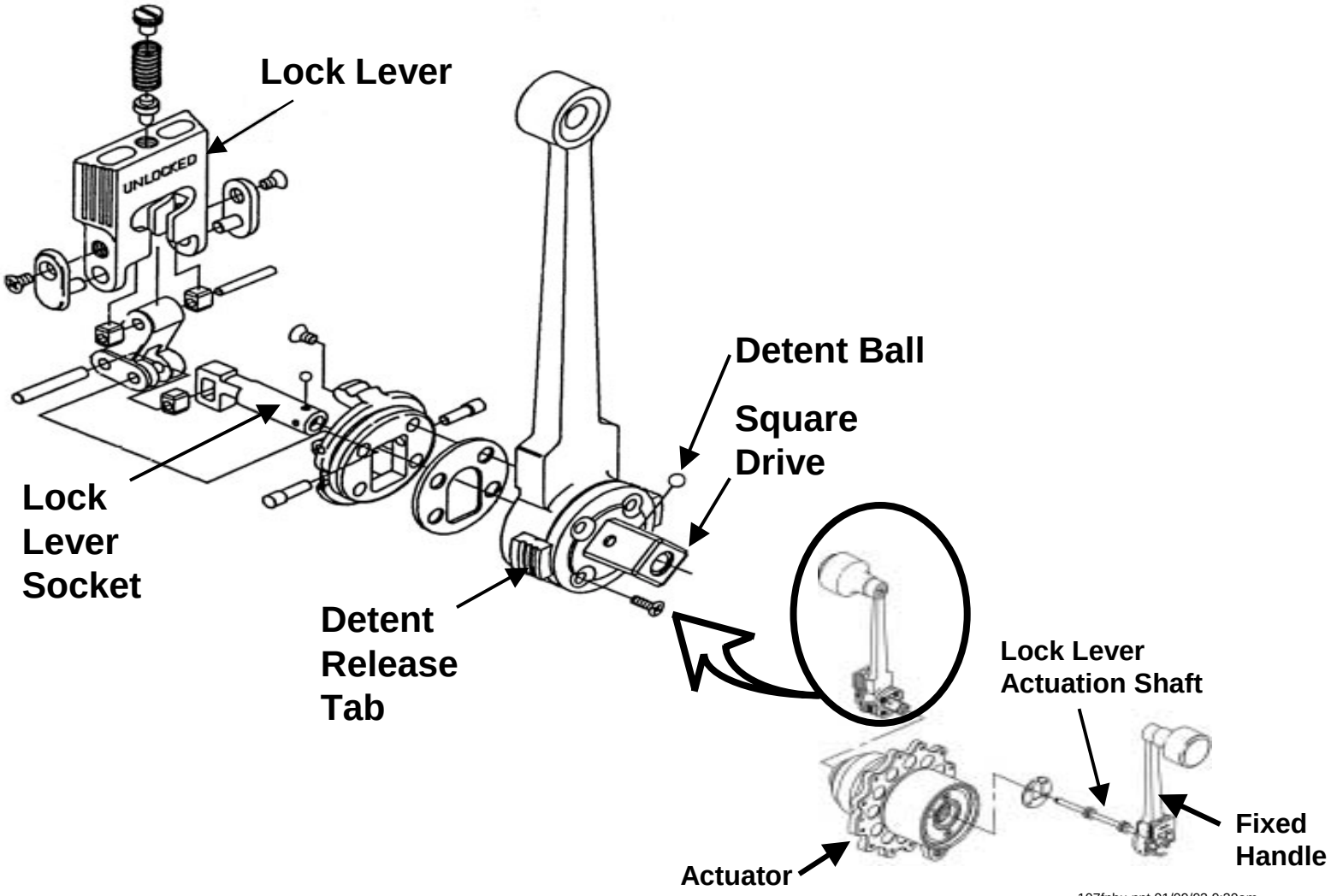
Concern:

- Inability to unlock the hatch actuator prevents the crew from unlatching the hatch and entering the airlock for EVAs (crit 1R/2)

STS-109-V-02: AIRLOCK A HATCH LOCKING DEVICE DIFFICULT TO ACTUATE

Presenter:

Organization/Date:
Orbiter 01/09/03



STS-109-V-02: AIRLOCK A HATCH LOCKING DEVICE DIFFICULT TO ACTUATE	Presenter:
	Organization/Date: Orbiter 01/09/03

Discussion:

- The removable handle on the crew module side of this actuator must be fully seated in order for the lock lever socket to be properly engaged
  - With the handle unseated, lock lever can move separately from the rest of the lock mechanism
- During final hatch closeout for flight, handle was noted to be fully seated, and actuator functioned properly

Actions Taken:

- On-vehicle post-flight troubleshooting revealed that the actuator handle release tabs did not spring back after being depressed
  - Handle became unseated when lock lever was moved
- Removed the handle/actuator assembly and sent it to the NSLD for TT&E and repair

STS-109-V-02: AIRLOCK A HATCH LOCKING DEVICE DIFFICULT TO ACTUATE	Presenter:
	Organization/Date: Orbiter 01/09/03

Actions Taken / Planned:

- Installed the spare assembly and successfully performed functional testing
- Will re-verify proper handle engagement after platforms are removed before launch
- Will consider adding permanent OMRSD requirement to verify proper handle engagement after platforms removed

STS-109-V-02: AIRLOCK A HATCH LOCKING DEVICE DIFFICULT TO ACTUATE	Presenter:
	Organization/Date: Orbiter 01/09/03

Risk Assessment:

- All hatch actuators on OV-102 have been functionally tested, with emphasis placed on verifying proper handle release tab operation
- Worst case, inability to unlock the “A” hatch actuator is a crit 1R/2 failure because it results in losing the ability to perform a contingency EVA if required

Flight Rationale:

- The actuator/handle was replaced, and functional verification has been completed
  - Permanent OMRSD requirement being considered

STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE	Presenter:
	Organization/Date: Orbiter 01/09/03

Observation:

- MPS LH2 4” disconnect failed to close pneumatically when commanded at MECO
  - Closed via back-up mechanical mode at ET/Orbiter umbilical separation

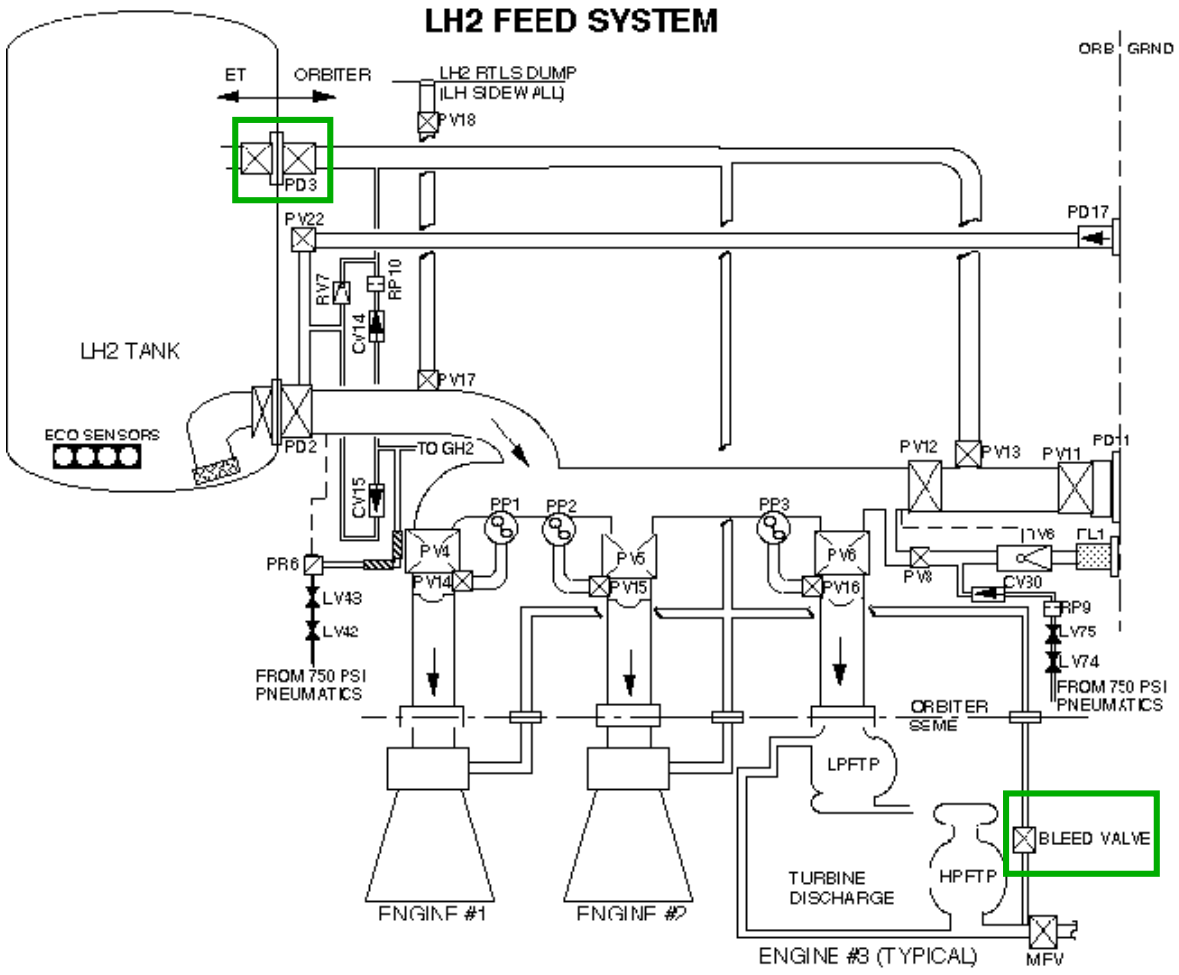
Concern:

- Failure of the 4” disconnect to close pneumatically in the case of a pre-MECO SSME shutdown or pad-abort results in inability to isolate the affected SSME from the hydrogen in the ET
  - No concern for nominal mission
    - Minor helium loss during entry if disconnect fails to close in back-up mechanical mode

STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE

Presenter:

Organization/Date:
Orbiter 01/09/03

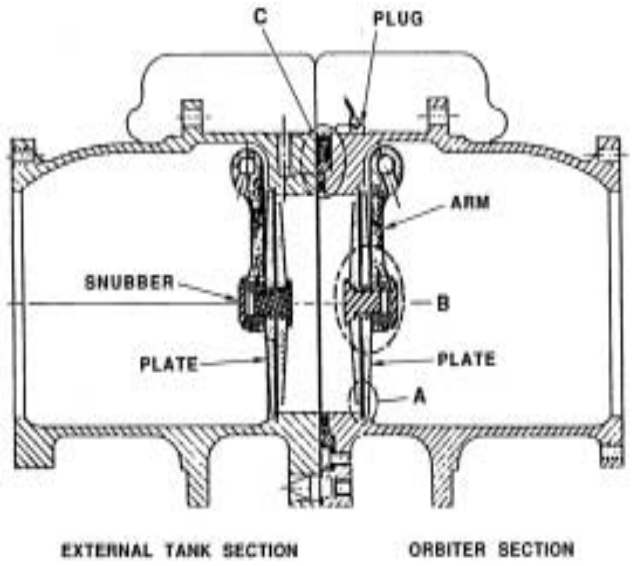


STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE

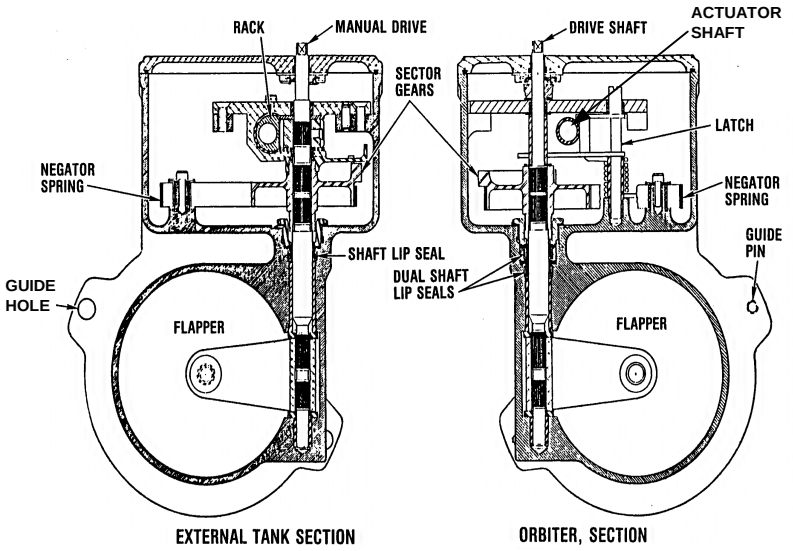
Presenter:

Organization/Date:
Orbiter 01/09/03

Orbiter/ET 4” Disconnect



MATED 4” DISCONNECT



DISCONNECT HALVES SEPARATED

STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE	Presenter:
	Organization/Date: Orbiter 01/09/03

Discussion:

- Previous failures of 4” disconnect to close pneumatically:
  - STS-29 – Disconnect failed to close pneumatically, closed at umbilical retract
    - Attributed to icing on ET side rack mechanism
  - STS-55 – Disconnect failed to close following a pad abort until LH_2 topping valve was opened
    - Actuator was replaced
    - During ascent, disconnect failed to close until umbilical retract
      - F/A could not repeat failure – closed as UA
  - STS-89 – Disconnect failed to close pneumatically, closed at umbilical retract
    - F/A could not repeat – closed as UA

STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE	Presenter:
	Organization/Date: Orbiter 01/09/03

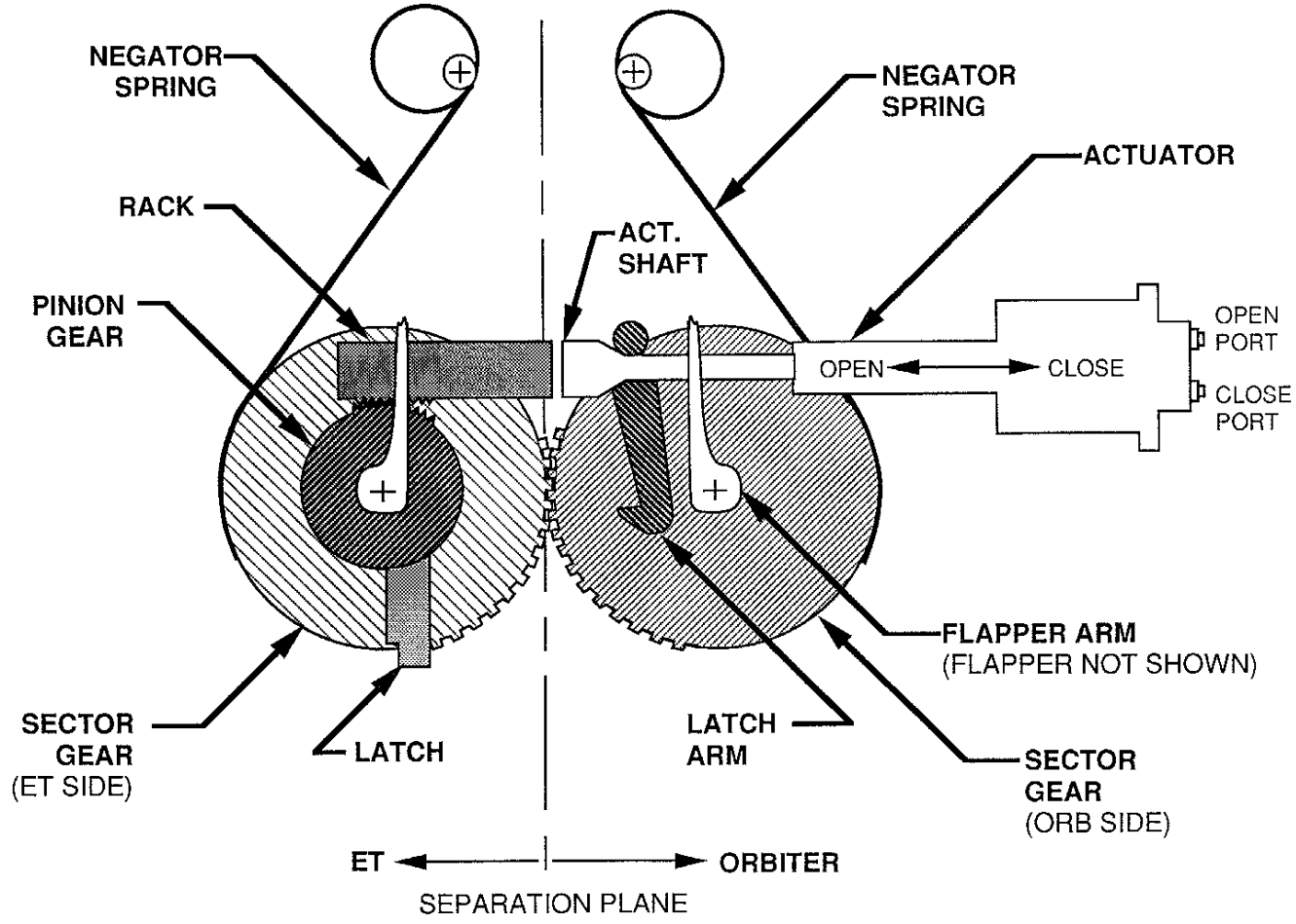
Actions Taken:

- Inspection of Orbiter disconnect post-landing for indications of failure
  - Initial runway inspection revealed nothing unusual
  - Borescope inspection found Flourogold spacer (spool which negator spring slides/rotates on) cut and bent in towards springs
    - Scuff mark found on back of housing
- Disconnect R&R complete
  - Borescoped new disconnect and verified no damage
  - Leak checks complete and good
  - Removed PD3 failure analysis to follow
    - Ambient & cryo cycle tests

STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE

Presenter:

Organization/Date:
Orbiter 01/09/03



STS-109-V-03: MPS 4-INCH RECIRCULATION DISCONNECT SLOW TO CLOSE	Presenter:
	Organization/Date: Orbiter 01/09/03

Risk Assessment / Flight Rationale:

- Disconnect failure to close pneumatically is only critical for uncontained SSME shutdown
  - Probability of SSME catastrophic shutdown is remote
- Borescoped new disconnect and verified no damage
- OMRS verification of disconnect function accomplished prior to propellant loading
- No history of disconnect failure to close via mechanical back-up separation mode
  - Prevents helium loss during entry

STS-109-V-04: FORWARD TRANSLATION HAND CONTROL -X CONTACT LOSS ANOMALY	Presenter:
	Organization/Date: Orbiter 01/09/03

Observation:

- During an STS-109 -X NC2 burn (MET 00:17:50), Channel C output from the forward Translation Hand Control (THC) dropped from logic one to zero three seconds before channels A and B

Concern:

- Loss of redundancy due to failure of one output channel on one axis of THC output

Discussion:

- Each of the six axis outputs of the THC has three electrically independent channels
- ATP requirement calls for the three output channels (A, B & C) of each axis to activate within 18 millisecs of each other
- Observed time difference between state changes of the three channels was considered to be abnormal THC operation

STS-109-V-04: FORWARD TRANSLATION HAND CONTROL -X CONTACT LOSS ANOMALY	Presenter:
	Organization/Date: Orbiter 01/09/03

Actions Taken:

- OV-102 and OV-105 forward and aft THCs were tested
  - All THCs operated normally during the Off-to-On grip movement in all axes
  - All axes showed little variation in switch-to switch tracking times when the grip was released normally
  - Each THC showed measurable variations in de-activation time between channels on some axes - when the grip was released slowly
- Three spare THCs showed similar operating characteristics when tested at NSLD under ATP conditions
  - All three spare THCs passed ATP requirements

STS-109-V-04: FORWARD TRANSLATION HAND CONTROL -X CONTACT LOSS ANOMALY	Presenter:
	Organization/Date: Orbiter 01/09/03

Conclusions:

- The THC anomaly on STS-109 was unexpected, but not unique to the OV-102 forward THC (S/N 002)
- On-to-Off switch tracking time variation larger than the Off-to-On requirement is a normal characteristic of the THCs
- All THCs switch normally when the grip is moved to hard stop, and released cleanly
- A “User Note” should be added by the using organizations to document the possibility of significant switching time differences IF the grip is held somewhere between null and hard stop

STS-109-V-04: FORWARD TRANSLATION HAND CONTROL -X CONTACT LOSS ANOMALY	Presenter:
	Organization/Date: Orbiter 01/09/03

Risk Assessment:

- For the reported anomaly, the THC is Criticality 1R/3
  - Each of the six axis outputs of the THC has three electrically independent and redundant channels
- The THC is Criticality 1R/2 only for the ET separation maneuver
  - In the event of the failure of the automatic -Z firing to provide ET separation, a manual command input using the THC would be necessary
  - 1R/2 Criticality is for a physically jammed THC which would be unable to provide any -Z firing command channels

STS-109-V-04: FORWARD TRANSLATION HAND CONTROL -X CONTACT LOSS ANOMALY	Presenter:
	Organization/Date: Orbiter 01/09/03

Flight Rationale:

- Post flight testing has shown that the reported anomaly is an unexpected, but normal, characteristic of the THCs
- Adequate system redundancy is in place
  - THC has three redundant outputs for each axis
- THCs have been functionally verified per OMRS requirements

STS-109-V-05: FES ACCUMULATOR/HI-LOAD FEEDLINE B HEATER SYSTEM 2 FAILURE	Presenter:
	Organization/Date: Orbiter 01/09/03

Observation:

- FES accumulator/hi-load H_2O feedline B (starboard) heater system 2 zone 4 failed off

Concern:

- Without corrective action, loss of a second heater may result in FES feedline freezing and potential loss of one of the FES water supply systems

Discussion:

- Accumulator line temperature (V63T1894A) and hi-load feed line temperature (V63T1896A) dropped to 50 °F & 60 °F respectively at MET 008:15:15 indicating a heater failure
- The crew switched to heater string 1 and the system performed nominally for the remainder of the mission

STS-109-V-05: FES ACCUMULATOR/HI-LOAD FEEDLINE B HEATER SYSTEM 2 FAILURE	Presenter:
	Organization/Date: Orbiter 01/09/03

Actions Taken:

- Post-flight troubleshooting isolated the problem to a bad thermal switch
  - Switch (S0V63S51) was replaced and successfully retested
  - In addition, the feedline B accumulator line temp sensor (V63T1894A) was not responding during troubleshooting
    - Sensor was also replaced and successfully retested

Risk Assessment:

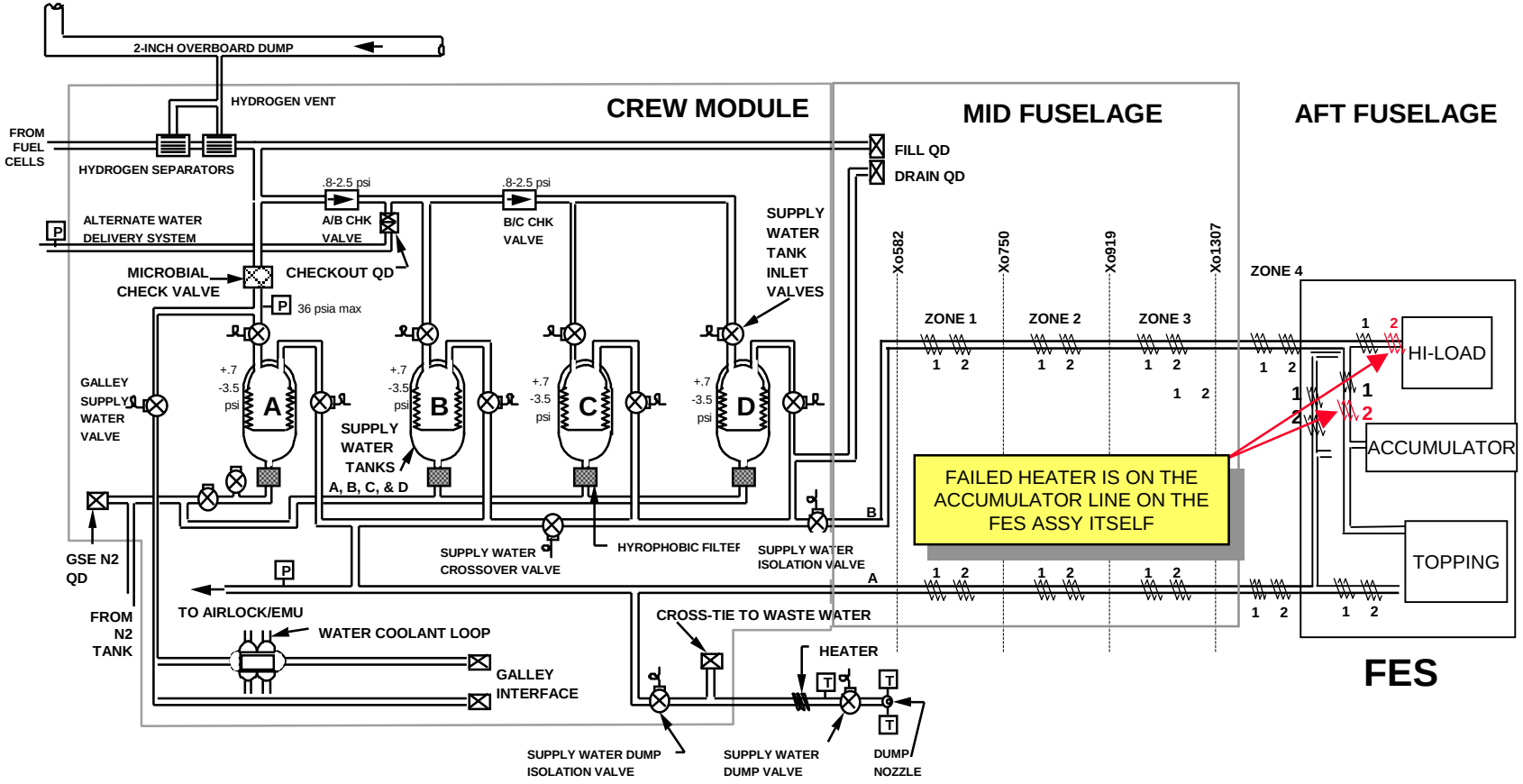
- Heater is criticality 1R3
  - There are two redundant heater strings per feedline, providing temperature control to prevent freezing
  - In the event of a second heater string failure, a contingency line purging procedure is also in place to prevent freezing and recover the line for entry

STS-109-V-05: FES ACCUMULATOR/HI-LOAD FEEDLINE B HEATER SYSTEM 2 FAILURE

Presenter:

Organization/Date: Orbiter 01/09/03

SUPPLY WATER SYSTEM



STS-109-V-05: FES ACCUMULATOR/HI-LOAD FEEDLINE B HEATER SYSTEM 2 FAILURE	Presenter:
	Organization/Date: Orbiter 01/09/03

Flight Rationale:

- Problem was isolated to a bad thermal switch which has been replaced
  - Post-repair verification - good results
- There are two redundant heater strings per feedline, providing temperature control to prevent freezing
- With loss of both heater strings, a contingency procedure is in place to purge the affected line to prevent freezing (safing) and allow recovery of the system for entry
  - Redundant feedline (A) maintains FES capability

STS-109-V-06: RCS THRUSTER R3R FAILED OFF	Presenter:
	Organization/Date: Orbiter 01/09/03

Observation:

- Thruster R3R failed off during RCS hotfire

Concern:

- Loss of RCS thruster redundancy

Discussion:

- R3R (S/N 635) failed off during first commanded firing
  - Chamber pressure (Pc) reached max value of 11.2 psia
  - RM deselected thruster
- Fuel and ox flow was evident by drop in injector temps
- Low Pc and injector temp drop indicate partial flow on one valve and full flow on other valve
- First flight for this thruster since last installation / flushing
- Most likely causes are fuel valve extrusion or ox valve nitrates
- Thruster was deselected for remainder of mission

STS-109-V-06: RCS THRUSTER R3R FAILED OFF	Presenter:
	Organization/Date: Orbiter 01/09/03

Actions Taken:

- Failed thruster R3R has been removed and replaced
  - Required entire manifold R&R to prevent sympathetic failures
- Failed thruster sent to WSTF for TT&E
  - Ox and fuel valves passed GN2 response test
  - No contamination found in Pc tube
  - Pc transducer functioned normally
  - Analysis of water flush effluent showed relatively low quantities of metallic contamination
- Cause of failure not conclusively determined, however most likely cause is failure of ox valve to open due to nitrate contamination
  - Evidence of minor ox leakage seen during ground turnaround
  - Bellows R&R on other manifold 3 thruster inlet line could potentially allow moisture into system

STS-109-V-06: RCS THRUSTER R3R FAILED OFF	Presenter:
	Organization/Date: Orbiter 01/09/03

Risk Assessment:

- Failed off thruster is Crit 1R/3
  - Redundant thrusters exist in all firing directions
  - Extensive flight history of failed off thrusters
    - Well documented and understood failure mode
- Risk mitigation actions are in place
  - Preventative maintenance flushing performed on all primary thrusters at OMM, as well as those used for in-flow replacements
  - Full manifold R&R required for any thruster removal to preclude collateral damage
  - GN2 chamber purge implemented during turnaround operations to reduce propellant vapor build-up
  - Molecular sieve of oxidizer implemented at KSC

STS-109-V-06: RCS THRUSTER R3R FAILED OFF	Presenter:
	Organization/Date: Orbiter 01/09/03

Flight Rationale:

- Manifold 3 thrusters were removed and replaced
- Redundant thrusters exist for each firing direction
- Flight rules exist for failed off thrusters
- Not a safety of flight issue
  - RM provides protection by deselecting thruster
- Risk mitigation actions in place to reduce failures

STS-109-V-07: EV1 EMU WATER LEAK & SUSPECT DPS & BC VOLTAGE SPIKE

Presenter:	
Organization/Date:	Orbiter 01/09/03

Observation:

- During the STS-109 mission, the EV1 EMU experienced a water leak of ~1 gallon when the feedwater shutoff valve that feeds the sublimator opened inadvertently

Concern:

- Impact to the crew's on-orbit timeline
- Risk associated with water intrusion

Discussion:

- EMU 1 data indicated a sublimator pressure of 11.8 psia (s/b same as cabin pressure ~10.2 psia) indicating a feedwater shutoff valve leak
- EV1 was powered by EMU Dual Power Supply & Battery Charger (DPS & BC) side 1 and EV2 was powered by EMU DPS & BC side 2
  - The two sides of the EMU DPS & BC are independent

STS-109-V-07: EV1 EMU WATER LEAK & SUSPECT DPS & BC VOLTAGE SPIKE	Presenter:
	Organization/Date: Orbiter 01/09/03

Discussion (cont):

- EMU DPS & BC may have induced a voltage spike which caused the water valve to open
  - Previous occurrence prior to STS-77
    - Troubleshooting showed that the condition could occur with a specific combination of EMU and DPS & BC
    - DPS & BC output voltage transients were caused by greater than ICD load from the EMU fan when in the speed control mode
  - STS-109 data review did not reveal a spike, however voltage is only sampled at 1 sample/second
- EMU DPS & BC was redesigned in 1997 to limit output voltage overshoot, preventing inadvertent energizing of an EMU shutoff solenoid valve
  - Output voltage is limited to 22 vdc using a "clamp down" feature
  - Prototype unit has been tested with EMU suits

STS-109-V-07: EV1 EMU WATER LEAK & SUSPECT DPS & BC VOLTAGE SPIKE	Presenter:
	Organization/Date: Orbiter 01/09/03

Discussion (cont):

- Installation of upgraded units across the fleet was delayed to resolve a concern over low charge current status (vehicle instrumentation) during OMRSD testing
  - Issue surfaced during first on-vehicle checkout of new unit
  - Lab testing and analysis determined that a summation of tolerances within the vehicle instrumentation system would cause the low charge current status
  - OMRSD was revised to account for system “losses”
  - New unit has successful missions on STS-110, -111, -112 and -113

STS-109-V-07: EV1 EMU WATER LEAK & SUSPECT DPS & BC VOLTAGE SPIKE	Presenter:
	Organization/Date: Orbiter 01/09/03

Actions Taken:

- The new EMU DPS & BC was installed
- Testing to determine cause of anomaly is in work
  - EMU testing indicated no anomaly
  - DPS & BC was tested at the NSLD with no anomalies
- EPD&C PRT concluded that the most probable cause of the STS-109 anomaly was output voltage spikes induced by the old configuration EMU DPS & BC

Risk Assessment:

- No risk for STS-107
- New DPS & BC installed which will prevent a voltage spike causing EMU feedwater shutoff valve to open

STS-109-V-07: EV1 EMU WATER LEAK & SUSPECT DPS & BC VOLTAGE SPIKE	Presenter:
	Organization/Date: Orbiter 01/09/03

Flight Rationale:

- Installation of an upgraded unit addresses the most probable cause of the STS-109 anomaly
  - No EVAs scheduled for STS-107
- Operation of the upgraded DPS & BC with the EMUs will be verified prior to flight
- Upgraded unit has performed successfully on past four shuttle orbiter missions

	Presenter:
	Organization/Date: Orbiter 01/09/03

CONFIGURATION CHANGES AND CERTIFICATION STATUS

BACKUP

CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:

Organization/Date:
Orbiter 01/09/03

OV-102 STS-107 Modifications and Certification

Mission Requirements

MCR/Modification	Certification Method			Certification Approval Request No.	Approval Date	Remarks
	Test	Analysis	Similarity			
MCR 19240 ET Yoke Assembly Part Number Change				N/A		• Updates Orbiter/ET forward attach installation drawing to reflect -510 yoke for light weight ET
MCR 19627 EDO Pallet Logo Update Mission Kit MV0458A				N/A		• Adds Boeing/U.S. flag logos on pallet insulation blanket assembly
MCR 23061 New SCM Battery Mission Kit MV0221A FIRST FLIGHT	X	X		01-20-39115204	5/1/02	• Replaces expended obsolete 2.8 vdc battery (Catalyst Research 3440) with a new 3.6 vdc battery (Tadiran TL 5134)

CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:

Organization/Date:
Orbiter 01/09/03

OV-102 STS-107 Modifications and Certification

Corrective Action

MCR/Modification	Certification Method			Certification Approval Request No.	Approval Date	Remarks
	Test	Analysis	Similarity			
MCR 11618 Hydraulic Pump Washer Change Out		X		04-30-580100-001F	3/26/02	• Replaces (18) washers with improved fitting washers and relaxes torque to preclude washer damage
MCR 17177 MPS Helium Tank Gap Verification				N/A		• Verifies gap between anti-rotation arm and the adjusting bolt head is between 0.000" and 0.002"
MCR 18755 Sky Genie Installation Mission Kit MV0607A		X	X	05-25-661607-001E	5/3/02	• Installation provides new fastening provisions for attaching the Sky Genie bags to the flight deck ceiling
MCR 18755 CDR/PLT Seat Actuator Cap Retention Cover Mission Kit MV0225A			X	07-25-39129185-301F	9/24/02	• Adds cover to retain the manual drive mechanism actuator hex cap, which is susceptible to becoming de-bonded
MCR 18755 MA9N Frame Assembly Redesign Mission Kit MV0669A		X	X	03-25-000907-001B	6/24/02	• Fabricates new frame assembly to eliminate interference with the MA16N locker door

CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:

Organization/Date:
Orbiter 01/09/03

OV-102 STS-107 Modifications and Certification

Corrective Action (cont)

MCR/Modification	Certification Method			Certification Approval Request No.	Approval Date	Remarks
	Test	Analysis	Similarity			
MCR 19285 OMS/RCS Cross-feed Line Heater Installation Modifications				N/A		• Relocates temp sensor & reduces heater wrap concentration correcting off-nominal temperature response observed during the previous flight (STS-109)
MCR 19309 Crew Hatch Carrier Panel FRSI Plugs				N/A		• Installs crew compartment side hatch door external insulation FRSI plugs in open insert holes preventing airflow erosion of sub insulation (filler bar)
MCR 19376 Milson Fastener Redesign			X X	07-25-661612-001F 09-25-660511-001H	7/5/01 6/25/01	• Installs redesigned Milson fasteners on the avionics bays 1, 2, & 3A thermal debris panels (3) and orbiter structure

CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:

Organization/Date:
Orbiter 01/09/03

OV-102 STS-107 Modifications and Certification

Process Improvements

MCR/Modification	Certification Method			Certification Approval Request No.	Approval Date	Remarks
	Test	Analysis	Similarity			
MCR 11618 Removal of Inactive DFI Tile				N/A		• Completes removal of two inactive DFI temperature measurements above crew compartment window #2 (deferred from flight 27)
MCR 18224 Flipper Door Material Change Dimensional Check				N/A		• Completes remaining gap measurement dimensional checks confirming proper spacing (no preload) between all castellated nuts and clevis fittings
MCR 19427 Removal of Seal Leak Check Extension from F1 Joint				N/A		• Removes seal leak check extension stem from the leak check port on F1 joint • Improves installation of F1 foam insulation segments
MCR 19555 Flipper Door #1 Blade Seal Spring Modification		X		20-07-198000-001Q	11/16/01	• Replaces inboard elevon aerothermal blade seal springs with stiffer springs allowing improved reseat against the elevon mating surface

CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:

Organization/Date:
Orbiter 01/09/03

OV-102 STS-107 Modifications and Certification

Process Improvements (cont)

MCR/Modification	Certification Method			Certification Approval Request No.	Approval Date	Remarks
	Test	Analysis	Similarity			
MCR 19560 FRCS Thermal Clip Deletion		X		137-01-320101-058H	1/8/03	• Deletes thermal transfer clips from interface between FRCS module and lower forward fuselage • Thermal analysis determined that the clips are not required • Deletion reduces ground processing time
MCR 19563 Micro-WIS 12th Strain Gauge Measurement Addition Mission Kit MV0886A				N/A		• Installation of 12th GFE Micro-WIS strain gauge unit assembly in support of orbiter life certification
MCR 19648 Aft Ballast Shim Modification				N/A		• Adds thicker shim configuration and positive stops to preclude shims from sliding out of the ballast containers

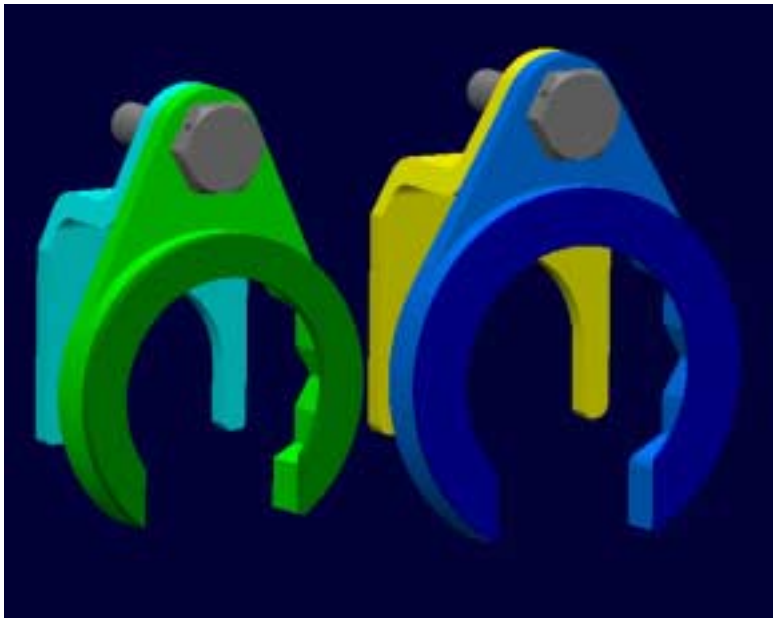
CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter:
	Organization/Date: Orbiter 01/09/03

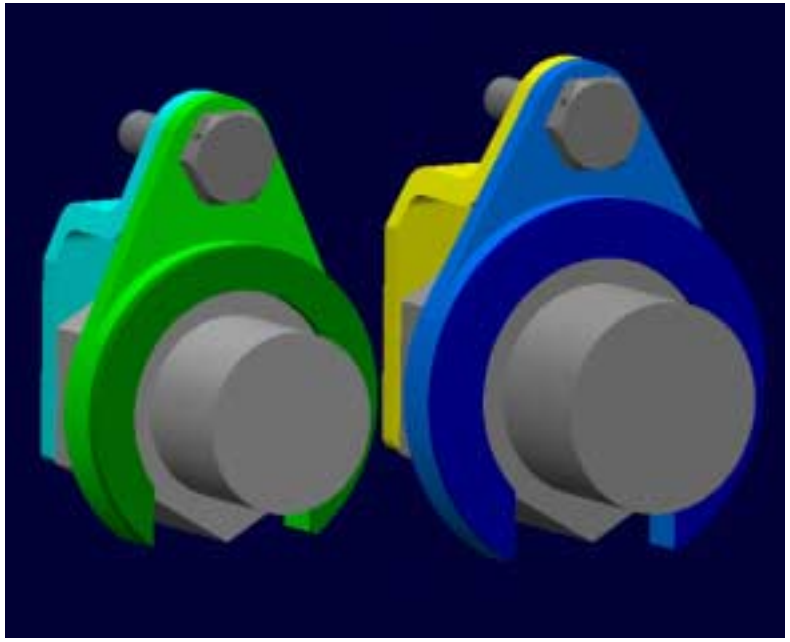
FRCS Dynatube B-nut Retainers Installed by MR:

- Low “break-away” torques noted on LP01 (OV-103) thruster Dynatube fittings lead to pre-load relaxation concern
  - Seal saver from L1A found damaged due to incorrect installation
- OMS/RCS PRT recommended removal of FRC2 to install retainers, ultimately to protect against joint separation due to an improperly installed seal saver
  - FRC2 is only pod/module without safety wire on thruster Dynatube fittings
- Retainers were designed to capture Dynatube fittings with provision for installation of safety cable
- Stress/Dynamics assessment verified acceptability for flight
- FRC2 to be modified to OV-103 & subs safety-wire configuration at next OMDP

CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter:
	Organization/Date: Orbiter 01/09/03

FRCS Dynatube B-nut Retainers Installed by MR: (Cont)





Approximate Dimensions: 2” height
1.5” width
0.65” depth

Weight of Assembly: 1.8 oz oxid, 1.45 oz fuel

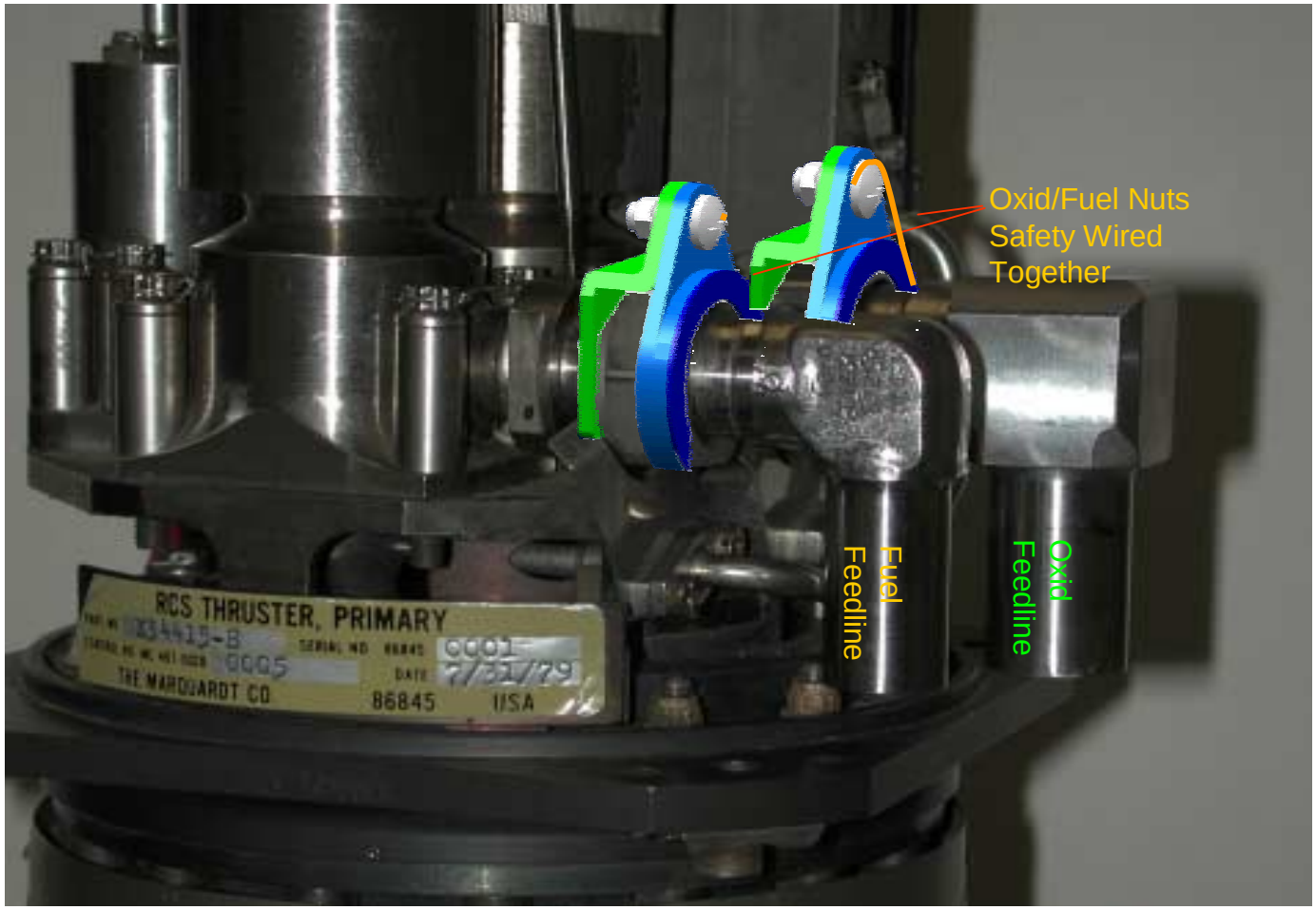
Material: CRES 304

Bolt: NAS1003-2H

Nut: MD114-1001-0104

CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter:
	Organization/Date: Orbiter 01/09/03

FRCS Dynatube B-nut Retainers Installed by MR: (Cont)



CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter:
	Organization/Date: Orbiter 01/09/03

Left OME Pitch Clevis Mount Machined by MR Action in Order to Attach Pneumatic Pack:

- Original clevis mount on Orbital Maneuvering Engine (OME) S/N 116 not manufactured per print
  - The area where the pneumatic pack bracket attaches via two thru-bolts was inadvertently machined ~.021" oversize
  - PRT recommended replacement due to concerns with excessive play in the pneumatic pack bracket attachment and thinning of the clevis where it was machined
  - Replacement part was obtained from WSTF
- With new clevis mount installed, the pneumatic pack could not be attached due to misalignment of the bolt holes
  - Pneumatic pack attach structure also not per print - fillet radius too large, causing clevis mount tangs to contact fillet before bolt holes are in alignment

CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter:
	Organization/Date: Orbiter 01/09/03

Left OME Pitch Clevis Mount Machined by MR Action in Order to Attach Pneumatic Pack: (Cont)

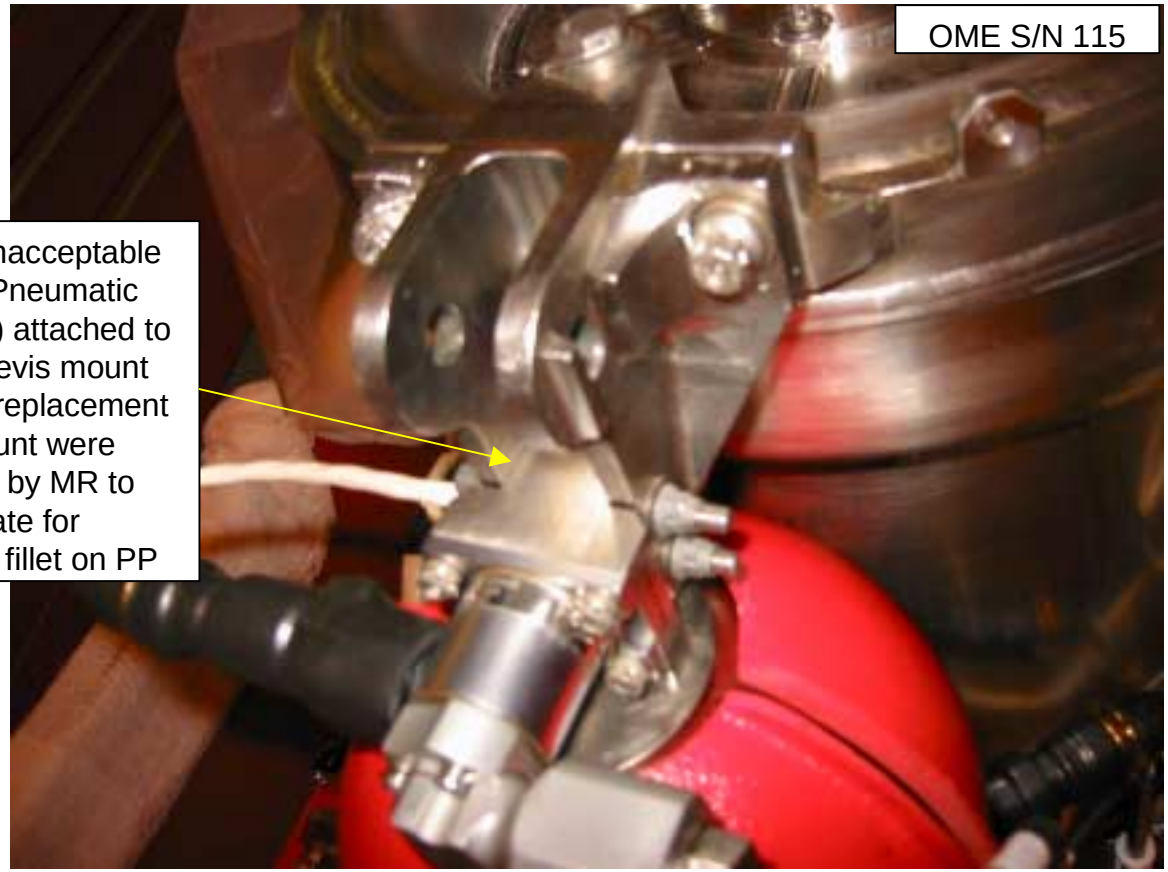
- Plan was developed to machine clevis tangs to compensate for oversized fillet (chamfer 0.08” off edges)
- Boeing/JSC Stress verified integrity of the clevis mount is not adversely affected
  - Chamfer does not protrude into bolt holes
- Measurements of both the removed part and the replacement part verified acceptable difference in pitch actuator mounting hole location without adjustment of actuator
- Travel and Response and Heat Shield Clearance checks were performed during OMS/RCS Flight Control Checkout (OMI V1238) with no anomalies

CONFIGURATION CHANGES AND CERTIFICATION STATUS

Presenter:

Organization/Date:
Orbiter 01/09/03

OME Pitch Clevis Mount (Actuator Not Installed)

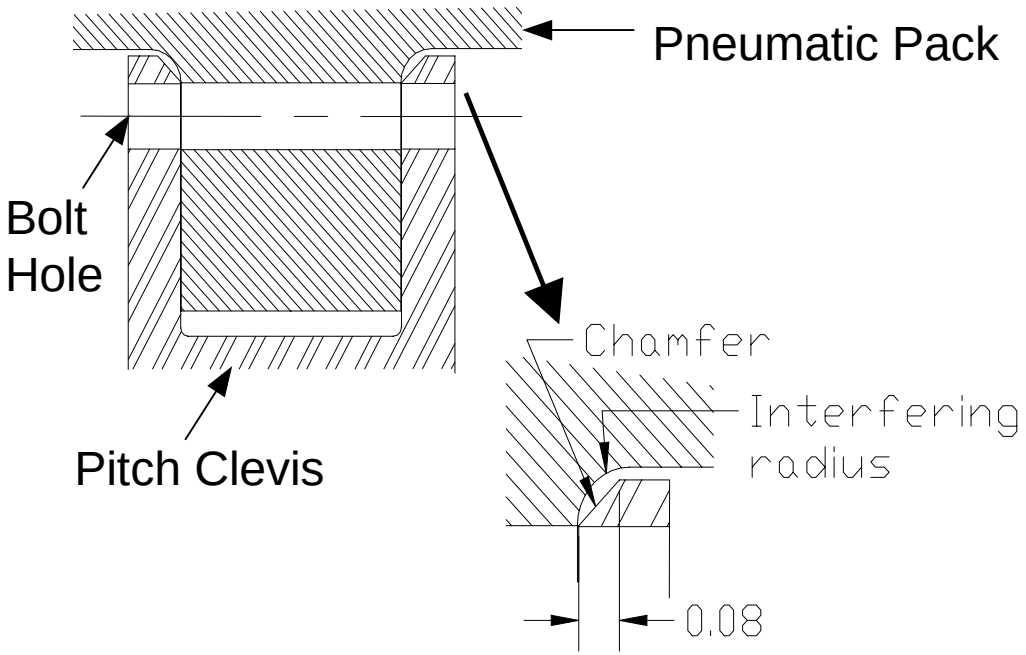


- Area of unacceptable gap with Pneumatic Pack (PP) attached to original clevis mount
- Tangs of replacement clevis mount were machined by MR to compensate for oversized fillet on PP

CONFIGURATION CHANGES AND CERTIFICATION STATUS	Presenter:
	Organization/Date: Orbiter 01/09/03

Modified (Chamfered) OMS Engine Pitch Clevis

Top view of pitch clevis modification
OMS engine S/N 116



	Presenter:
	Organization/Date: Orbiter 01/09/03

MISSION KITS
BACKUP

MISSION KIT MODIFICATION SUMMARY	Presenter:
	Organization/Date: Orbiter 01/09/03

Orbiter Mission Kit Related Modifications:

- MV0221A New SCM Battery
- MV0225A CDR/PLT Seat Actuator Cap Retention Cover
- MV0458A EDO Pallet Logo
- MV0607A Sky Genie Fastener Change
- MV0669A MA9N Frame Assembly Redesign
- MV0886A Micro-WIS 12th Strain Gauge Measurement

	Presenter:
	Organization/Date: Orbiter 01/09/03

Special Topic
Back-Up Charts

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

Thermal / Mechanical Cycle Profiles

Ball	Line	Thermal	Slow Fill (lbf)	Nominal (lbf)	MEOP (lbf)	1.5X (lbf)	1.75X (lbf)
2.24”	LO2 17”	LN2	11,000	41,000 + / - 15,000*	49,000 + / - 15,000*	61,000 + / - 22,500*	71,000 + / - 26,500*
1.75”	LO2 12”	LN2	6,200	24,000 + / - 16,500*	28,000 + / - 16,500*	36,000 + / - 25,000*	42,000 + / - 29,000*
1.25”	LH2 17”/ 12”	LH2	3,000	10,400 + / - 7,700*	14,800 + / - 7,700*	15,600 + / - 11,600*	18,200 + / - 13,500*

*200 cycles at 0.5 Hz

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

History of Methods to Crack Test Samples

Ball	Test Sample ID	Notch	Notes
2.24”	HB-2.24-2a	Y	275 F to –100 F to crack
	HB-2.24-2b	Y	Dual EDM notches; Rapid thermal cycles (212 F to 32 F) to crack
	MSFC-2.24-1	Y	400 F to –100 F to crack
	MSFC-2.24-2	N	300 F to –100 F to crack
1.75”	MSFC-1.75-1	Y	EC / CT indications; Rapid thermal cycles (212 F to 32 F) to crack
	MSFC-1.75-2	N	Eddy Current indications; LN2 dunk (Amb to –320 F) to crack
1.25”	MSFC-1.25-1	Y	375 F to –100 F to crack
	MSFC-1.25-2	N	Not cracked

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

Testing Summary

Ball	Test Sample ID	Branching Cracks	Material Islands	Loss of Parent Material	ECD
2.24”	HB-2.24-2a	Yes	Yes	No	1/9/03
	HB-2.24-2b	No	No	No	1/9/03
	MSFC-2.24-1	Yes	Yes	Yes	1/9/03
	MSFC-2.24-2	Yes	Yes	Yes	1/11/03
1.75”	MSFC-1.75-1	Yes	Yes	No	1/11/03
	MSFC-1.75-2	No	No	No	1/9/03
1.25”	MSFC-1.25-1	Yes	Yes	No	1/12/03

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

Logistics Ball Status

PN	Name	NHA Name	NHA P/N	Qty	Location	S/N	Remarks
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	1	KSC VAB	1I15-1655-F-5	Shipped from NSLD for NDE 12/17/02
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	1	KSC VAB	9Z13	Shipped from NSLD for NDE 12/17/02
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	2	KSC VAB	12H10-1606F	Shipped from NSLD for NDE 12/17/02
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	1	Boeing HB	07-92-001	Shipped from AP residual for NDE 12/17/02
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	1	Boeing HB	07-92-003	Shipped from AP residual for NDE 12/17/02
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	1	Boeing HB	07-92-004	Shipped from AP residual for NDE 12/17/02
10950-59-3-9	Ball 2 1/4"	17" LOX BSTRA	10950-159	1	Boeing HB	07-92-006	Shipped from AP residual for NDE 12/17/02
10950-58-3-9	Ball 1 3/4"	12" LOX BSTRA	10950-185	5	NSLD	J15-1655F-5	To be transferred to KSC M&P for NDE 1/2/03
10950-58-3-9	Ball 1 3/4"	12" LOX BSTRA	10950-185	1	NSLD	12H10-1606F	To be transferred to KSC M&P for NDE 1/2/03
10950-58-3-9	Ball 1 3/4"	12" LOX BSTRA	10950-185	3	AP	TBD	To be transferred to KSC M&P for NDE 1/2/03
10950-58-3-9	Ball 1 3/4"	12" LOX BSTRA	10950-185	2	MSFC	TBD	Shipped from AP Residual 12/20/02
10950-60-3-9	Ball 1 1/4"	17" & 12" LH2 BSTRA	10950-166	4	NSLD	5D8-5	To be transferred to KSC M&P for NDE 1/2/03
10950-60-3-9	Ball 1 1/4"	17" & 12" LH2 BSTRA	10950-166	4	NSLD	9Z13	To be transferred to KSC M&P for NDE 1/2/03
10950-60-3-9	Ball 1 1/4"	17" & 12" LH2 BSTRA	10950-166	1	NSLD	8X20-1	To be transferred to KSC M&P for NDE 1/2/03
10950-60-3-9	Ball 1 1/4"	17" & 12" LH2 BSTRA	10950-166	15	AP	TBD	To be transferred to Boeing HB M&P for NDE 1/2/03
10950-60-3-9	Ball 1 1/4"	17" & 12" LH2 BSTRA	10950-166	2	MSFC	TBD	Shipped from AP Residual 12/20/02
2.25"	COTS Ball	Non Flight	N/A	5	MSFC	None	Direct Purchase from Mountain Alloy 12/20/02
2.25"	COTS Ball	Non Flight	N/A	3	Boeing HB	None	Direct Purchase from Mountain Alloy 12/20/02
2.25"	COTS Ball	Non Flight	N/A	2	Boeing JSC	None	Direct Purchase from Mountain Alloy 12/20/02

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

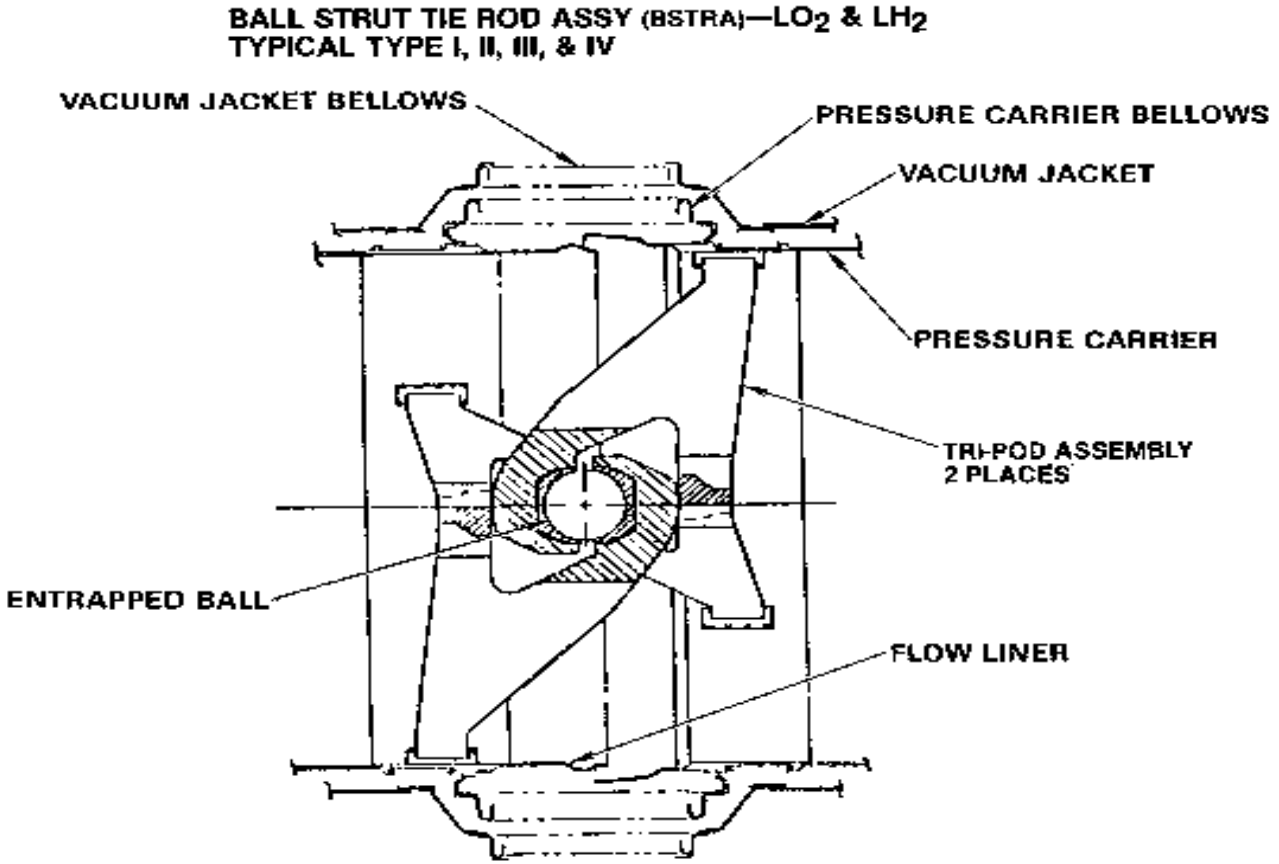
Team Structure:

- TMT - Ouellette, Snyder/Stefanovic, Mulholland, Grush, Browne, Reith/Rigby
- Qual and Test History - Peller, Baird
- Build Data - Fineberg, Baird
- Inspections - Frazer, Wagner, Allison
- M&P - Christensen, Jacobs, Curtis, Allison, Munafo
- Stress - Dunham, Kramer-White, Madera, Rocha
- Test - Peller, Applewhite, Templin, Munafo
- Vehicle Ops & Line Removal - Young, Albright, Dinsel
- Logistics - Saluter

- Web Sites
  - USA Hou - http://usa1.unitedspacealliance.com/usahou/projects/orbiter/support/mpsbstracracks.htm
  - Boeing Hou - http://hou-web02.tx.boeing.com/sfoc/orbiter/mps/BSTRAcrack.htm
  - USA KSC - http://usa1.unitedspacealliance.com/usago/orgs/eng330/mps-ssme/BSTRA_Crack/BSTRA_Crack.htm

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

Typical BSTRA Assembly

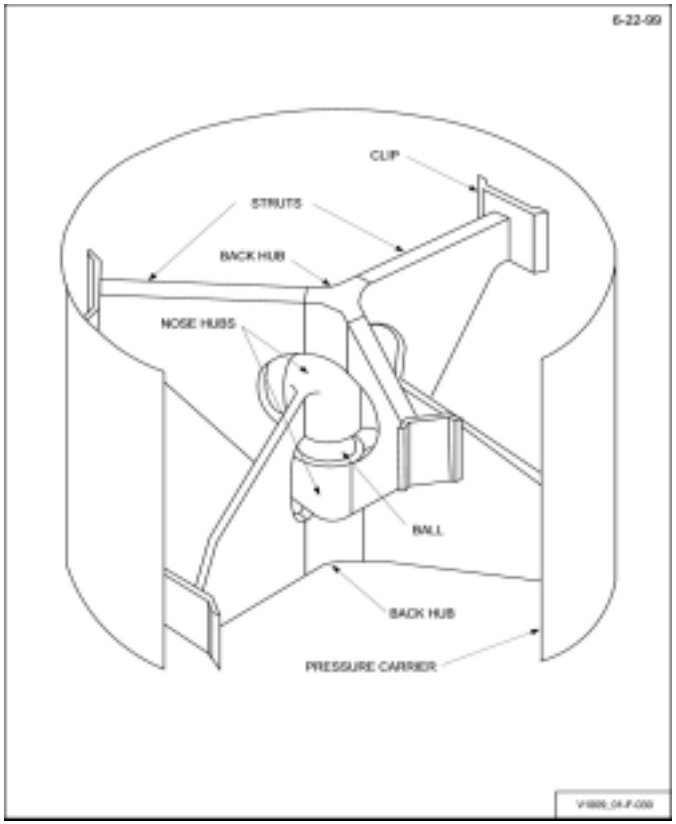


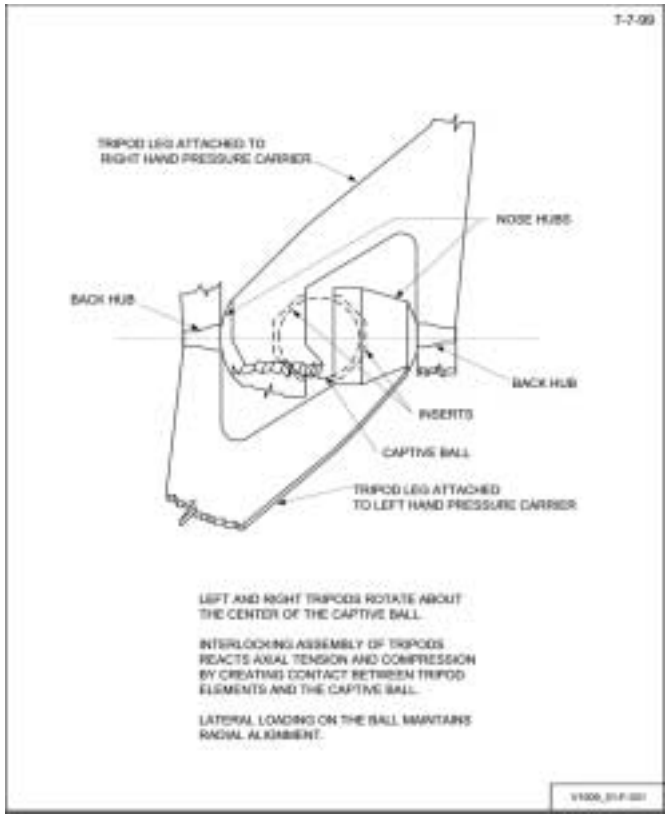
MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

Typical BSTRA Assembly





MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: History of Stoody Bearings in the Space Shuttle

- Stoody #2 is a cobalt based alloy developed for use in bearings
- Despite the material being uncharacterized for our use environment this material was selected based on its similarity to a material used successfully in the Saturn Program in a similar application (Stellite Star J)
- Testing by MSFC in 1978 found Stoody #2 to have a coarse microstructure (property variability) and extreme crack sensitivity
- Stoody #2 bearings were already installed in the MPTA and cost and schedule considerations made it highly desirable to not change materials
- Numerous discussions were held between the technical communities resulting in several test programs
- The apparent conclusion reached after all of the above was that risk of failure was low; recommendation was to continue with MPTA

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

1977 Arrowhead Qualification Test Summary

2 ¼ 100 thermal cycles –320/+150 400 load cycles 50/90 kips –320°F

2 ¼ 400 thermal cycles –320/+150

1 ¾ 400 thermal cycles –320/+150

1 ¼ 100 thermal cycles –425/+150 100 load cycles 2/20 kips –423°F

Results:

Defect free by penetrant and metallurgical sectioning

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

1978 MSFC Testing Summary

2 ¼ (x5)	10 thermal cycles –320/+212	100 load cycles 1.5x design max –320°F
5/8 (x6)	10 thermal cycles –320/+212	100 load cycles 1.5x dmax –320°F
7/16 (x6)	100 combined cycles –300/+600	1.25 dmax with vibration
1 ¼ (x2)	100 thermal cycles –423/+150	100 load cycles 1.1 dmax –423°F

Follow up testing of Cracked Balls

2 ¼ (3)	100 load cycles 1.5x design max –320°F
5/8 (3)	100 load cycles 1.5x dmax –320°F

Results:

2 ¼: No cracks observed, had to artificially induce cracks to test – no growth observed post test - 2 balls were found to be cracked by eddy current (2 of 5)

5/8: 3 cracks discovered after first five thermal cycles, no growth noted in rest of test 2 of the uncracked balls were discovered by metallurgical sectioning to be cracked (5 of 6)

7/16: No cracks observed during test, post test eddy current found two balls cracked and metallurgical sectioning found another (3 of 6)

1 ¼: One crack observed on receipt (eddy current), no growth noted during test (1 of 2)

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: Interpretation of Material Data

- Stoody #2 has nil ductility at room temperature; assume this still applies at cryo
  - Brittle Material - low resistance to thermal/mechanical shock
- Coarse Microstructure
  - Results in property variations
  - Large acicular carbide precipitates
    - Stress concentration sites for crack initiation if at surface
- Largest thermal cycle occurs at manufacture
  - On casting, cools from roughly 2400°F to ambient; forms residual stresses
  - Followed by stress relief heat treatment; 1650°F for four hours with slow cool to ambient
    - Supposed to relieve residual stresses to manageable level
  - Cracks detected on receipt in 1978 MSFC test are most probably due to above cooling stresses

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: Failure Mechanism

- Initial cause of cracks is not related to mechanical loads
  - Service load is compression
    - Hertzian stresses would produce spalling which is a localized chipping at the surface
      - Not observed in MSFC failures or on OV-103
  - Mechanical impact
    - Would expect hertzian stresses at impact location, again would produce spalling
      - Not observed in MSFC failures or on OV-103

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: Failure Mechanism (cont):

- Data to date supports a thermal mechanism
  - Outer surface of bearing is trying to shrink as temperature decreases
    - Produces tensile stresses at outer fibers of bearing
    - Any scratches, nicks, casting defects, or other surface imperfections would act as stress concentrations and support crack initiation
  - Cracks would be circumferential
    - As observed in MSFC failures and on OV-103

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: Flight Rationale Support

- Crack Arrest
  - Assumed mechanism is thermal stresses with possible residual casting stresses
    - Residual casting stresses would be relieved by crack formation
    - Thermal stresses can only grow crack if delta T increases
      - In brittle material, with no restraints, once initiated crack would propagate until stress at crack tip dropped below the ultimate strength of the material
      - Subsequent temperature cycles below that delta T could not produce a higher stress at the crack tip

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: Flight Rationale Support (cont):

- FOD Generation (Spalling)
  - No reports of spalling at crack edges in 1978 MSFC report
  - No evidence of spalling at crack edges in what can be seen of the OV-103 crack
  - Conversations with two bearing suppliers provided anecdotal evidence that fractures are clean (no FOD)
  - Spalling would be against the strongest property of this material
    - Compressive strength is 300,000 psi

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

M&P: Conclusions

- Concur with 1978 MSFC observation that material has a coarse microstructure with extreme crack sensitivity
- Concur with conclusion that risk of failure is low given use conditions and thermal screening
- Use of dye penetrant inspection as detection method for pre-existing cracks or post-acceptance screening is inadequate to detect cracks

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

Stress: Loads Analysis

- Verification that LH2 line model changes, part of flowliner activity, does not impact PE cert loads is in work
  - Comparison of LH2 random vibration loads indicate model changes reduce line loads
    - PE still considered enveloping case
  - Vibration environments at the ET Attach end on the 17” disconnect were reviewed
    - Vibration in –014 spec and PE analysis is consistent with DFI flight data
  - Work on LO2 and transient environments is ongoing
- Mechanical loads schedule has been defined for testing

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack	Presenter:
	Organization/Date: Orbiter 01/09/03

Stress: Stress Analysis

- Stress Analysis will be performed on BSTRA ball alone FEM that can simulate cracks
  - Thermal gradient and mechanical contact loads
  - Checkout runs for 2.24” uncracked balls nearing completion

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

LH2 17” Feedline Qualification Testing Summary

- ATP
  - Proof Press / Operational / Elevated Amb Temp / PC Leakage / VJ Pressure Rise
- Endurance
  - 2000 cycles @ 72%, 200 cycles @ 90%, 45 psig @ -300F
- Pressure Cycles
  - 50 cycles extended @ 90%, 50 cycles compressed @ 90%, 5 – 55 psig @ -300F
- Temperature Cycles
  - 100 cycles, Amb to -423F within 10 minutes
- Vibration
  - 13.3 Hours/axis, -400F @ ~20 – 35 psig
- Heat Transfer
  - LH2 @ 5 psig
- Jacket Implosion
  - 22 psid across VJ @ ambient
- Pressure Carrier Implosion
  - 30 psid across PC @ ambient
- Pressure Cycles
  - 1140 cycles total, 5 – 55 psig @ -300F
- Burst
  - 5 min @ 83 psig, ambient
- Post Test Inspection 6/9/82 – Some PC collapsing during implosion testing due to mislocated support. No BSTRA related anomalies.

MPS 17” Feedline Ball Strut Tie Rod Assembly Ball Crack

Presenter:

Organization/Date:
Orbiter 01/09/03

LO2 17” Feedline Qualification Testing Summary

- ATP
  - Proof Press / Operational / Elevated Amb Temp / PC Leakage / VJ Pressure Rise
- Endurance
  - 2000 cycles @ 72%, 200 cycles @ 90%, 200 psig @ -300F
  - Some excessive operational noise report at 1700 cycles – Cause ???
- Pressure Cycles
  - 50 cycles extended @ 90%, 50 cycles compressed @ 90%, 5 – 200 psig @ -300F
- Temperature Cycles
  - 100 cycles, Amb to -300F within 10 minutes @ 20 psig
- Vibration
  - 13.3 Hours/axis, -300F @ ~70 – 180 psig
  - Some VJ leaks noted and corrected
- Heat Transfer
  - LO2 @ 5 psig
- Jacket Implosion / Pressure Carrier Implosion
  - 22 psid across VJ @ ambient / 30 psid across PC @ ambient
- Pressure Cycles
  - 1940 cycles total, 10 – 220 psig @ -300F
- Burst
  - 5 min @ 395 psig, 3 min @ 440 psig, ambient
- Post Test Inspection 11/6/78 and 6/9/82 – Some movement of one support. No BSTRA related anomalies. No mention of actual tear-down.